Comparison of Proposed Kite Architecture with P-Hexagon for Directional Sensor Network

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Abstract-While considering the Wireless Sensor Network (WSN), many problemswere encountered related to connected coverage in directional sensor networks. The idea is to deploy directional sensors which work on ultra wide bands, thereby, making wireless electronic data communication possible across a network. In this paper,a consideration on the problems of a connected network to cover either a set of point locations (Connected Point-Coverage Deployment ->CPD) or the entire sensing region (Connected Region-Coverage Deployment ->CRD) has been done. An Introduction has been made to KITE architecture in sectors like, sensing range to cover the entire coverage region. A validation of the merits of the proposal has been analysed and compared to the existing work with the help of extensive simulation result.

Keywords-Wireless sensor networks, CPD, CRD, KITE.

I. Introduction

In wireless sensor networks, sensors are deployed to cover either certain set of points or the entire region. Hence, connected coverage in WSN is still a critical research issue. WSN assumes Omni- directional sensors with disk like sensing range [1-3]. However, the sensors may only sense a directional sector- like sensing a range due to various surrounding constraints (equipment and environmental). In this paper, an elucidation in some of the problems that are related to directional sensor networks has been madewith the proposal of the KITE architecture, in order to increase the Connected Region-Coverage in directional sensor networks.

The remainder of this paper has been organized as follows: Section II discussed about the connected coverage problems in directional sensor networks.

Section III described the model and thus formulated our problem. In Section IV, a deployment of KITE for CRD has been proposed with its further evaluation and performance measures using simulation results. Section V, concluded the paper with some future research directions.

II. Connected Coverage Problems In Directional Sensor Networks

When directional sensors are deployed at any location within a sensing region, two major problems came into existence, which were as follows: Connected Point- Coverage Deployment (CPD) and Connected Region- Coverage Deployment (CRD), which uses a minimum number of directional sensors to cover a set of point locations and the entire sensing region, respectively.

CPD is a NP-hard problem [4] as it is a sub problem of covering a set of points with a minimum number of sectors, commonly termed as Geometric Sector Cover (GSC), is NP-hard[1]. Polynomial- time solutions with provable approximation ratios have been provided for CPD [7].

CRD is related to the covering problem in Computational Geometry. The objective of CRD is to find deployment patterns with minimum covering density to place directional sensors as a connected network to cover a two- dimensional area. Recently it has been proved that the optimal covering density of any fat convex body [5] K is $||K|| / ||H(K)||$ [6], where H(K) is a hexagon with maximum area inscribed in K. In [7] two deployment patterns with bounded covering density for CRD are presented.

III. Model and Problem Formulation

The existing work on Connected Region-Coverage Deployment (CRD) covered a set of points in a region using convex sectors and used a tiling body as ***P-hexagon*** to cover the sector [7].

In this paper, a description about KITE architecture has been proposed to deploy directional sensors in order to form a connected network to cover a region.

In our model,a consideration about a stationary directional sensors, whose sensing ranging is of similar sector as above, with, sensing radius r_s and sensing angle $\alpha(\pi/3 \leq \alpha < \pi)$ has been made. An assumption has been taken about both the sensors and data sinks which communicates Omni-directionally with a communication radius r_c. Throughout the paper an usage of $S(r_s, r_c, \alpha)$ represents directional sensors, and $S(r_s.\alpha)$ represents a sector with radius r and angle α.

A proposed model of KITE [Fig. 1] has a composition of four edges as a tiling body to cover the maximum area within the sector. The assumption has been followed in [2], [3] and the area is presumed to be covered in sufficiently large amount, so that coverage waste beyond the boundary can be omitted.

IV. KITE for CRD and simulation results

This section defines the KITE architecture and discusses the deployment of KITE in CRD. It shows the variations in

DOI: 03.LSCS.2013.3.539

sensor radius thereby, increasing Connected Coverage-Region using simulation results.

As shown in fig. for sector $s(r_s,\alpha)$, OO' denote the centre of the sector and the middle point of the arc, respectively.

This sector has been placed in anxy-coordinate system where O coincides with the origin, and O' resides on the y-axis. The end points A and D were picked from the arc of the sector, in order to find OA and OD as two long equal edges of the kite (to cover the maximum area of the sector) such that ||OA||=||OD||=r. Joining O'A and O'D, it can be found that, OAO'D formulates a kite. The corresponding deployment pattern using such kites to achieve connected region-coverage is similar to [7].

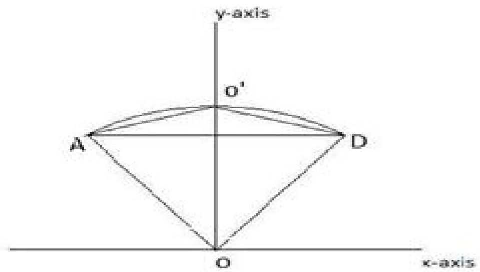


Fig. 1 Find the inscribed Kite OAO'D in a sector $S(r_s, \alpha)$.

Similar to [7] a calculation has been made for 'h' for strip-based deployment pattern using directional sensors $S(r_c,r_s,\alpha)$.

$$h = r_s\left(1 + \sqrt{r_s^2 - r_c^2\,\frac{4sin^2\alpha}{2}} - r_c\cos\left(\frac{\alpha}{2}\right)\right) \qquad (1)$$

Relay sensors are deployed between each pair of strips to guarantee network connectivity [7]. Now keeping **'r_c' =2 versus w=1**as constant we take the decreasing as well as increasing values of **'r_s'**respectively and calculate the value of **'h'**. The calculation [Fig. 2] and simulation results [Fig. 3-4] designed in Matlab2007 thus obtained are as below.

```
rs=[5 4 3 2 1];
rss=rs.^2;
rcc=[2 2 2 2 2];
rc=rcc.^2;
al=4*sin(pi/6) .^2;
al1=sin(pi/6) .^2;
x1=rc.*al;
w=1;
x11=w.*al1;
h=rs.*(1+sqrt(rss-x1)-rcc.*cos(pi/6))
h1=rs.*(1+sqrt(rss-x11)-w.*cos(pi/6))
grid on;
subplot(2,1,1);
plot(rs,h)
title('PROPOSED KITE ARCHITECTURE WHEN rc=2');
subplot(2,1,2);
plot(rs,h1)
title(' P-HEXAGON WHEN w=1');
```

Fig2: Matlab Code for the Simulation Done for Proposed Kite Architecture

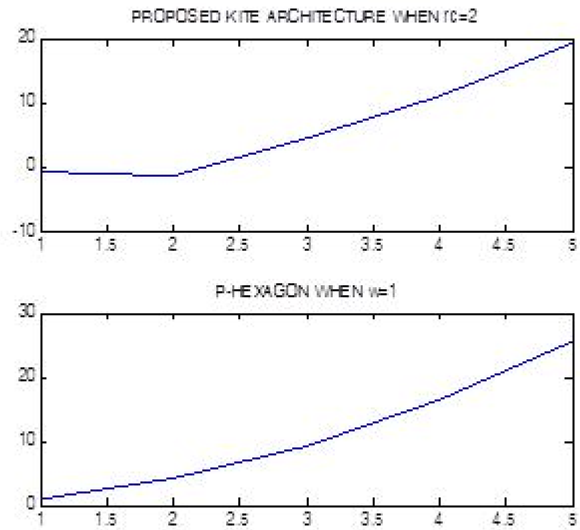
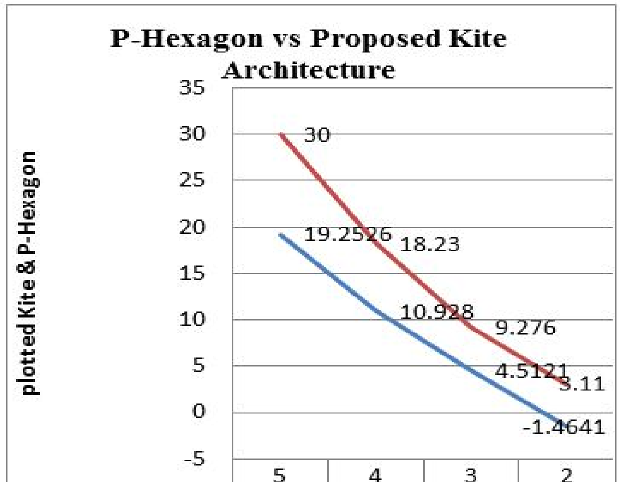


Fig 3: Proposed Simulation Graph for the coding done



	5	4	3	2
Kite Algorithm	19.2526	10.928	4.5121	-1.4641
P-Hexagon Algorithm	30	18.23	9.276	3.11

Fig 4.- Proposed Kite Architecture vs P-Hexagon Plot

The simulation results depicted that compared to the P-Hexagon [7] provide better connected region coverage using Proposed KITE architecture [Fig. 4]. Also when predicted for the higher value of factor **'r_s'** we tend to differ in the predicted output and the range deviation is more. Also approaching to lower values' they tend to predict the different variation.

V. Conclusion and future work

In this paper, a novel model of KITE architecture has been proposed to provide maximum coverage of a region using directional sensor networks. To the best of our knowledge, KITE architecture is the first to provide maximum connected region coverage. Via simulation results, it has been conclude that KITE model enhances the CRD in directional wireless sensor networks.Future work includes, finding better architecture to connected region coverage deployment, with higher order of connectivity.

DOI: 03.LSCS.2013.3.539

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DOI: 03.LSCS.2013.3.539